Interconnection Feasibility Study Report
GIP-IR605-FEAS-R1

Generator Interconnection Request 605
104.5 MW Wind Generating Facility
Windsor County, NS

2022-04-04

Control Centre Operations
Nova Scotia Power Inc.

Executive Summary

The Interconnection Customer (IC) submitted a Network Resource Interconnection Service (NRIS) Interconnection Request for a proposed 104.5 MW wind generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2024-12-31. The Point of Interconnection (POI) requested by the customer is the 138kV line L-6054, approximately 2.8 km from 101V- MacDonald Pond.

There are five transmission and three distribution Interconnection Requests in the Advanced Stage Transmission and Distribution Queue that must be included in the study models for IR#605. In addition, there is a long-term firm Transmission Service Reservation (TSR) that must be accounted for: 550 MW from New Brunswick to Nova Scotia (TSR-411). The TSR is expected to be in service in 2025 and a system study is currently underway to determine the associated upgrades to the Nova Scotia transmission system. These upgrades are expected to materially alter the configuration of the transmission system in Nova Scotia. As a result, the following notice was posted to the OASIS site at https://www.nspower.ca/oasis/generation-interconnection-procedures:

> *Effective January 19th, 2021, please be advised that the completion of advanced-stage Interconnection Studies under the Standard Generator Interconnection Procedures (GIP) may be delayed pending the outcome of the Transmission Service Request (TSR) 411 System Impact Study, which is expected to identify significant changes to the NSPI transmission system. The revised expected completion date for the study is February 28, 2022. Feasibility Studies initiated prior to the completion of the TSR System Impact Study will be performed based on the current system configuration.*

This study assumes that the addition of generation from IR#605 will displace coal-fired generation in eastern Nova Scotia for NRIS.

The interconnection with line L-6054 will require a t-tap and a single circuit breaker with the transfer trip protection to the IR#605 generation facilities. As IR#605 has dispersed generation totalling more than 75 MVA, each generator will be classified as a NERC Bulk Electric System (BES) element. The 34.5 kV bus and the 138kV bus would also be considered BES. There is the potential for an exclusion from BES to be granted for the high side (138kV) bus based on further analysis per the NS BES Exception Procedure. This analysis will be initiated as part of the System Impact Study (SIS) and exclusion from BES will only be granted upon subsequent approval by the Nova Scotia Utility and Review Board.

The assessment of the POI on the 138 kV line L-6054 indicated that several thermal loading violations would occur due to IR#605, notably L-6054 and L-6004. It is proposed that:

1. Uprate L-6054 between 43V and IR#605 POI (22.3 km) from 75°C to 85°C, as well as the metering change at the 43V end.
2. Modification of NSPI protection systems to L-6054 at 43V-Canaan Road, IR#605 and 101V-MacDonald Pond to three-terminal line protection. If the breaker for L-6054 at 43V opens for any reason (manual or protection) then a transfer trip will be sent to IR#605 breaker.

No violations of voltage criteria were found for IR#605.

The IC indicated that IR#605 will be utilizing the Enercon E160 EP5 E3 wind turbines with the FT option. Based on the typical impedances of the transformers, IC provided collector circuit length and typical collector circuit impedances, IR#605 may nearly be able to meet the net power factor of +0.95 to -0.95 at the Interconnection Facility 138kV bus. As specific details of the collector circuits become available, the adequacy of reactive power supply will be further investigated in the System Impact Study. It is noted that the proposed Enercon E160 EP5 models do not meet the requirement to produce full Mvar capability down to zero MW output.

IR#605 was not found to adversely impact the short-circuit capabilities of existing circuit breakers. It is assumed that the project design meets NSPI requirements for low-voltage ride-through and voltage control. Harmonics must meet the Total Harmonics Distortion provisions of IEEE 519. The minimum short circuit ratio at the Interconnection Facility 138 kV bus is 6.7 with all lines in service and 4.0 with L-6054 open at 101V.

The preliminary value for the plant loss factor is calculated as -1.4% at the POI at L-6054, net of any losses on the IC facilities up to the POI.

The preliminary non-binding cost estimate for interconnecting 104.5 MW to the POI at L-6054, including the cost of a 138 kV circuit breaker with a line tap, the protection upgrades of L-6054 plus the uprate of L-6054 is $6,440,500. The cost estimate includes a contingency of 10%. In this estimate, $3,845,000 (plus 10% contingency) of the amount represents Network Upgrade costs which are funded by the Interconnection Customer, but eligible for refund under the terms of the GIP. The remainder of the costs are fully funded by the Interconnection Customer. This estimate will be further refined in the System Impact Study and the Facility Study.

The estimated time to construct the Transmission Providers Interconnection Facilities is 18-24 months, and the Network Upgrades are estimated to be completed 24-36 months after receipt of funds and cleared right of way from the customer.

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1 Introduction

The Interconnection Customer (IC) submitted a Network Resource Interconnection Service (NRIS) Interconnection Request for a proposed 104.5 MW wind generation facility interconnected to the NSPI transmission system, with a Commercial Operation Date of 2024-12-31. The Point of Interconnection (POI) requested by the customer is the 138kV line L-6054, approximately 2.8 km from 101V- MacDonald Pond.

The IC previously signed a Feasibility Study Agreement to study the connection of their proposed 154 MW wind generating facility to the NSPI transmission system dated 2021-07-06, and subsequently submitted a capacity reduction request for 104.5 MW. This report is the result of the updated Study Agreement dated 2021-09-21. This project is listed as Interconnection Request 605 in the NSPI Interconnection Request Queue and will be referred to as IR#605 throughout this report.

Figure 1 shows the proposed geographic location of IR#605 in relation to the NSPI transmission system.

Figure 1 IR#605 Site Location

Figure 2 is a simplified one-line diagram of the transmission system configuration in Valley NS. Figure 3 shows the circuit breaker configuration of transmission lines in the vicinity of the POI.

Figure 2 Point of Interconnection (not to scale)

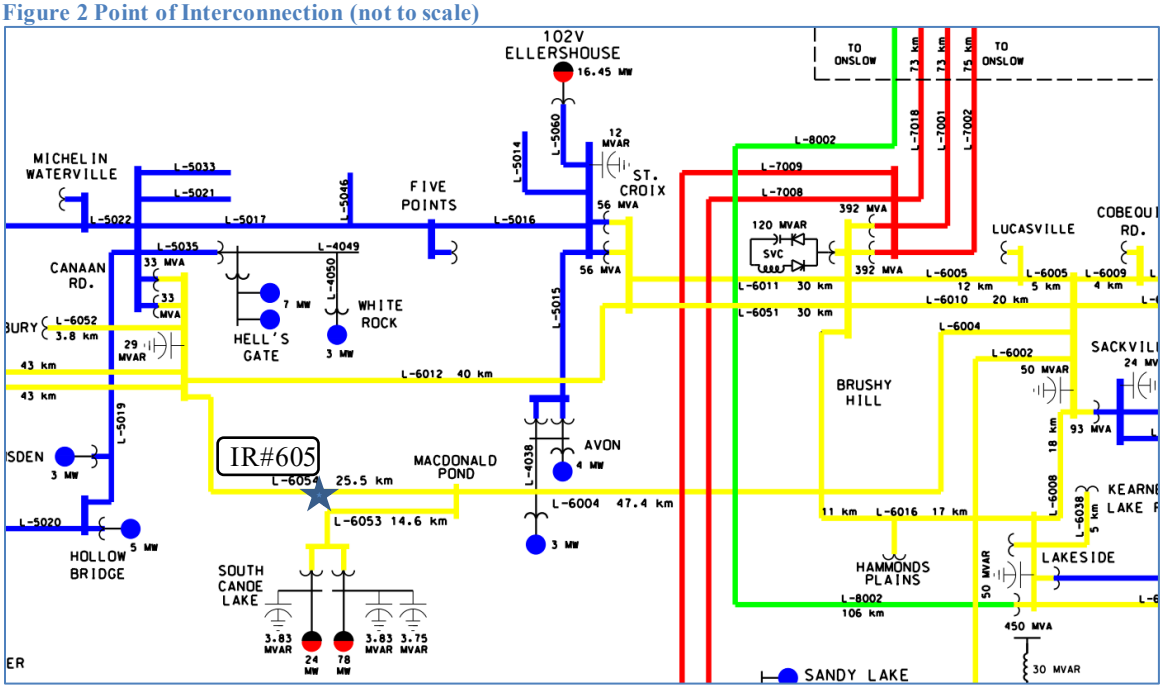
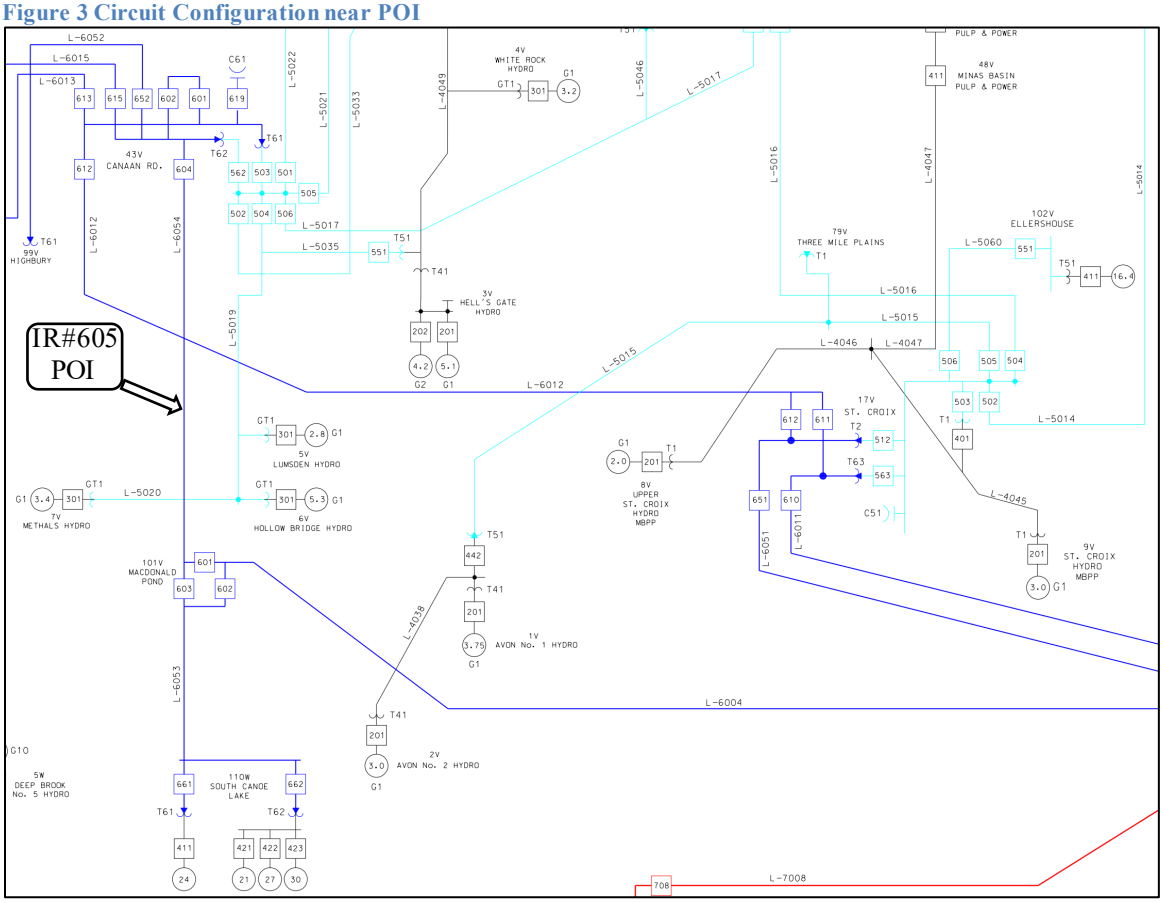


Figure 3 Circuit Configuration near POI



2 Scope

The objective of this Interconnection Feasibility Study (FEAS) is to provide a preliminary evaluation of system impacts from interconnecting the proposed generation facility to the NSPI transmission system at the requested location. The assessment will identify potential impacts on transmission element loading, which must remain within their thermal limits. Any potential violations of voltage criteria will be identified and addressed. If the proposed generation increases the short-circuit duty of any existing circuit breakers beyond their rated capacity, the circuit breakers must be upgraded. Single contingency criteria are applied.

The scope of the FEAS includes the modelling of the power system in normal state (with all transmission elements in service) under anticipated load and generation dispatch conditions. A power flow and short circuit analysis will be performed to provide the following information:

- Preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the interconnection, and any network upgrades necessary to address the short circuit issues associated with the IR. Expected minimum short circuit capability will also be identified for the purposes of Short Circuit Ratio analysis.

- Preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection and identification of the necessary network upgrades to allow full output of the proposed facility. Thermal limits are applied to the seasonal (summer/winter) emergency ratings of transmission elements. Voltage violations occur when the post-contingency transmission bus voltage is outside the range of +/-10% of nominal voltage.

- Preliminary analysis of the ability of the proposed Interconnection Facility to meet the reactive power, power quality and cold-weather capability requirements of the NSPI *Transmission System Interconnection Requirements*[1] (TSIR).

- Preliminary description and high-level non-binding estimated cost and time to construct the facilities required to interconnect the generating facility to the transmission system.

- For comparative purposes, the impact of IR#605 on incremental system losses under standardized operating conditions is examined.

This FEAS is based on a power flow and short circuit analysis and does not include a complete determination of facility changes/additions required to increase the system transfer capabilities that may be required to meet the design and operating criteria

[1] transmission-system-interconnection-requirements (nspower.ca)

established by NSPI, the Northeast Power Coordinating Council (NPCC), and the North American Electric Reliability Corporation (NERC). These requirements will be determined by a more detailed analysis in the subsequent interconnection System Impact Study (SIS). An Interconnection Facilities Study (FAC) follows the SIS to ascertain the final cost estimate to interconnect the generating facility.

3 Assumptions

This FEAS is based on the technical information provided by the Interconnection Customer. The Point of Interconnection (POI) and configuration is studied as follows:

1. NRIS as per section 3.2 of the Generator Interconnection procedures (GIP).

2. Commercial Operation date 2024-12-31.

3. The Interconnection Customer Interconnection Facility (ICIF) consists of up to 19 Wind Energy Converter System (WECS) units; Enercon E-160 EP5 E3 generator units (FT option), each rated at 5.56 MW AC; capped at a total of 104.5 MW, connected to collector circuits operating at a voltage of 34.5kV.

4. The POI on L-6054 is considered non-Bulk Power System facilities and will therefore use a line tap with single circuit breaker.

5. The ICIF is adjacent to the 138 kV transmission right-of-way and therefore will not need a spur line from the POI to the IC 138kV/34.5kV transformers.

6. The generation technology used must meet the NSPI requirements for reactive power capability of at least 0.95 capacitive to 0.95 inductive at the HV terminals of the IC substation step up transformer. It is also required to have high-speed Automatic Voltage Regulation to maintain constant voltage at the designated voltage control point during and following system disturbances as determined in the subsequent System Impact Study. The designated voltage control point will either be the low voltage terminals of the wind farm transformer, or, if the high voltage terminals are used, equipped with droop compensation controls. It is assumed that the generating units are not de-rated in their MW capability when delivering the required reactive power to the system.

7. Preliminary data was provided by the IC for the IC substation interconnection facility. The IC has proposed two identical Interconnection Facility transformers. Each transformer was rated at 51/68/85 MVA and modeled with a positive-sequence impedance of 7.5% on 51 MVA with an X/R ratio of 34. The IC indicated that these interconnection facility transformers have a wye-wye winding configuration with +/- 10% off-load tap changer. The impedance of each generator step-up transformer is 6.0% on 6 MVA with an assumed X/R ratio of 12.

8. Detailed collector circuit data was not provided, so typical data (R+jX = 0.01+j0.04 p.u. on system base 100 MVA) was assumed with the understanding that the net real and reactive power output of the plant will be impacted by losses through transformers and collector circuits.

9. The FEAS analysis assumes that IR's higher in the Generation Interconnection Queue and OATT Transmission Service Queue that have completed a System Impact Study, or that have a System Impact Study in progress will proceed, as listed in Section 4 below.

10. Material provided by the IC indicates the minimum operating temperature is 0°C, but it is assumed that the wind turbines are equipped with a "cold weather option" suitable for delivering full power at -30°C as per the TSIR.

11. Planning criteria meeting NERC Standard TPL-001-4 *Transmission System Planning Performance Requirements* and NPCC Directory 1 *Design and Operation of the Bulk Power System* as approved for use in Nova Scotia by the Utility and Review Board, are used in evaluation of the impact of any facility on the Bulk Electric System.

12. The rating of transmission facilities in the vicinity of IR#605 are shown in Table 1.

Table 1 Local Transmission Element Ratings

Line	Conductor	Design Temp	Limiting Element	Summer Rating Normal/Emergency	Winter Rating Normal/Emergency
L-6054	556.5 Dove	75°C	Conductor	174/191 MVA	210/231 MVA
L-6011	556.5 Dove	100°C	Conductor	215/237 MVA	242/266 MVA
L-6051	795 Drake	100°C	Conductor	268/295 MVA	287/316 MVA
L-6004	556.5 Dove	75°C	Conductor	174/191 MVA	210/231 MVA
L-6013	556.5 Dove	100°C	Conductor	215/237 MVA	242/266 MVA
L-6012	556.5 Dove	100°C	Conductor	215/237 MVA	242/266 MVA

4 Projects with Higher Queue Positions

All in-service generation is included in the FEAS, except for Lingan Unit 2, which is assumed to be retired.

As of 2021-10-25, the following projects are higher queued in the Advanced Stage Interconnection Request Queue and are committed to the study base cases:

- IR426: GIA executed
- IR516: GIA executed
- IR540: GIA executed
- IR542: GIA executed
- IR574: FAC complete

- IR598: FAC in progress

The following projects have been submitted to the Transmission Service Request (TSR) Queue:

- TSR411: SIS in progress

TSR-411 is a long-term firm point-to-point transmission service reservation in the amount of 550 MW from New Brunswick to Nova Scotia; The TSR is expected to be in service in 2025 and a system study is currently underway to determine the required upgrades to the Nova Scotia transmission system. As a result, the following notice has been posted to the OASIS site at https://www.nspower.ca/oasis/generation-interconnection-procedures:

> *Effective January 19th, 2021, please be advised that the completion of advanced-stage Interconnection Studies under the Standard Generator Interconnection Procedures (GIP) may be delayed pending the outcome of the Transmission Service Request (TSR) 411 System Impact Study, which is expected to identify significant changes to the NSPI transmission system. The revised expected completion date for the study is February 28, 2022. Feasibility Studies initiated prior to the completion of the TSR System Impact Study will be performed based on the current system configuration.*

5 Short-Circuit Duty / Short Circuit Ratio

The maximum expected (design) short-circuit level is 5,000 MVA (21 kA) on 138kV systems and 3,500 MVA (31.5 kA) on 69 kV systems. The fault current characteristic for this Enercon E-160 EP5 WECS is assumed as 1.2 times the rated current, or X'd = 0.8307 per unit on machine base MVA.

Short circuit analysis was performed using PSS®E for a classical fault study, 3LG and flat voltage profile at 1.0 p.u. V. The short-circuit levels in the area before and after this development are provided below in Table 2.

Table 2: Short-Circuit Levels. IR#605 on L-6054 Three-phase MVA (1)

Location	Without IR#605	With IR#605
All transmission facilities in service		
POI on L-6054 (138kV)	1337	1456
Interconnection Facility (138kV)	1337	1456
43V-Canaan Road (69kV)	817	833
43V-Canaan Road (138kV)	1298	1353
101V-MacDonald Pond (138kV)	1370	1481

Table 2: Short-Circuit Levels. IR#605 on L-6054 Three-phase MVA [1]		
Location	Without IR#605	With IR#605
Minimum Conditions (PA, LG1, ML In-Service)		
Interconnection Facility (138 kV), all lines in-service	705	823
Interconnection Facility (138kV), L-6054 open at 43V	494	612
Interconnection Facility (138kV), L-6054 open at 101V	422	540

[1] Classical fault study, flat voltage profile

The interrupting capability of the 138 kV circuit breakers at 43V- Canaan Road and 101V-MacDonald Pond is at least 6,000 MVA. The interrupting capability of the 69 kV circuit breakers at 43V- Canaan Road is at least 1,000 MVA. As such, the interrupting rating at these substations will not be exceeded by this development on its own.

Inverter-based generation installations often have a minimum Short Circuit Ratio (SCR) for proper operation of converters and control circuits. Based on the calculated short circuit levels, a POI on L-6054, and a 104.5 MW installation consisting of 19 WECS units each rated at 5.56 MW, the short circuit ratio would be 6.7 at the 138kV Interconnection Facility of the IR#605 substation with all lines in service and IR#605 offline. This falls to 4.7 with L-6054 open at 43V, and 4.0 if L-6054 is open at 101V.

6 Voltage Flicker and Harmonics

Flicker coefficient information was not provided for the E-160 EP5 E3 machine. However, it is known that Type 4 wind turbines typically have a flicker coefficient of 2.0 - 2.4 at angle of 85°, which is about half that of Type 3 machines. Voltage flicker will be further examined when data for the machine is made available for the SIS.

The generating facility is expected to meet IEEE Standard 519-2014 limiting voltage Total Harmonic Distortion (all frequencies) to a maximum of 2.5%, with no individual harmonic exceeding 1.5% on 138 kV.

7 Load Flow Analysis

The load flow analysis was completed for generation dispatches under system summer peak load and winter peak load conditions which are expected to stress the Western-Valley areas. Generation dispatch was also chosen to represent import and export scenarios that consider expected flows from the existing transmission service reservation associated with the Maritime Link, and scenarios where Maritime Link imports displace NS thermal generation.

Transmission connected wind generation facilities were typically dispatched at approximately 40%, except in the vicinity of IR#605. There is high co-relation between wind plants in the valley area, so it is reasonable to expect that these other wind plants would be near full output when IR#605 is at rated output. The cases and dispatch scenarios considered are shown in Table 3.

Table 3: Base Case Dispatch (MW) IR#605 On-Line

Case	MLI	NS-NB	CBX	ONI	LIN	TRE	Wind	Valley Import
SP02	449(1)	0	265	208	0	0	364	18
SP04	475	334	745	670	164	0	461	126
WP02	320	174	837	1,065	347	324	530	188

S - Summer W - Winter LIN – Lingan Gen TRE – Trenton Gen
(1) IR#605 displaces 62 MW of Lingan, 22 MW of Tupper plus 26 MW of MLI

For NRIS analysis, this FEAS added IR#605 and displaced coal-fired generation in Cape Breton, reducing Cape Breton Export (CBX) transfers and Onslow Import (ONI) transfers. Single contingencies were applied at the 230 kV, 138 kV and 69 kV voltage levels for the above system conditions with IR#605 interconnected to the POI at L-6054. Automated analysis searched for violations of emergency thermal ratings and emergency voltage limits for each contingency. Contingencies studied are listed in Table 4.

Table 4 Contingency List

Transmission Line	Transformer / Bus	Circuit Breaker Failure	Double Circuit Tower
L-7008, L-7009, L-5545, L-5546, L-6531, L-6006, L-6025, L-6002	99W: T61, T71, T72	90H: 611, 608, 605, 602, 612, 609, 606, 603, 610, 607, 601, 503, 506, 501	L-7008+ L-7009 L-7009+ L-8002
L-6012, L-6013, L-6054, L-6015, L-6052, L-6052, L-5017, L-5022, L-5035, L-5019, 50V-Load (138kV),	43V- T61, T62,	120H: 710, 711, 712, 713, 714, 715, 716, 720, 621, 622, 623, 624, 626, 627, 628, 629	L-6005+ L-6016 L-6011+ L-6010 L-6005+ L-6016
L-6051, L-6011, L-5014, L-5060, L-5015, L-5016	17V-T2, T63, T1		
L-5025*, L-6053, L-6004	51V- T61*, B51*, B52, B61		
L-5531, L-5532*, L-5026*	13V- B51, 11V-B51*		
L-6002, L-6009, L-6008, L-6003, L-5003, L-5004	90H: T1		
L-6005, L-6010, L-6011	120H: T71, T72		

*Indicates contingency was studied with/without RAS action

Results

The study shows that L-6054 between 43V-Canaan Road and IR#605 POI will be overloaded under the loss of L-6004 or 90H-605 contingency. Similarly, L-6004 will be overloaded under the contingency of 43V-T62, which results in line L-6054 opening from the 43V end. No contingencies resulted in a violation of voltage limit criteria. Table 5 shows the highest thermal overloads found.

Table 5 Contingencies Resulting in Highest Line Overload

Line	Line segment	Highest Overload (% of Emergency Rating)	Case	Contingency
L-6054	43V-Canaan Road / IR#605 POI	Summer: 104%	SP02	L-6004 or 90H-605
L-6004	90H- Sackville/ IR#605 POI	Summer: 104%	SP02	43V-T62 or 43V-562

The following options are required for the L-6054 and L-6004 overloads (classified as Network Upgrades funded by the IC but eligible for refund under the GIP):

1. Uprate L-6054 between 43V and IR#605 POI (22.3 km) from 75°C to 85°C. This line uses a Dove 556.5 kcmil ACSR. The metering upgrade at the 43V end is also needed. The total estimated cost is $3,375,000;
2. Modification of NSPI protection systems to L-6054 at 43V-Canaan Road, IR#605 and 101V-MacDonald Pond to three-terminal line protection. If the breaker for L-6054 at 43V opens for any reason (manual or protection) then a transfer trip will be sent to IR#605 breaker.

These overloads will be further validated in the SIS.

8 Reactive Power and Voltage Control

In accordance with the *Transmission System Interconnection Requirements* Section 7.6.2, IR#605 must be capable of delivering reactive power at a net power factor of at least +/- 0.95 of rated capacity to the high side of the plant interconnection transformer(s). Reactive power can be provided by the asynchronous generator or by continually acting auxiliary devices such as STATCOM, DSTATCOM or synchronous condenser, supplied by the Interconnection Customer.

The information (Figure 4) provided by Enercon indicates that the Enercon E-160 EP5 E3 -FT 5.56 MW WECS have a rated power factor of 0.90 lagging and leading (+/- 2.7 Mvar per WECS) at the machine terminal voltage of 1.0 p.u. or above, from 10% to 100% of rated power. However, the NSPI Transmission System Interconnection Requirements (Section 7.6.2) requires that rated reactive power shall be available through the full range of real power output of the Generating Facility, from zero to full power. It is noted that the proposed Enercon models do not meet the requirement to produce full Mvar capability down to zero MW output.

Figure 4: Model E-FT WECS Reactive Capability

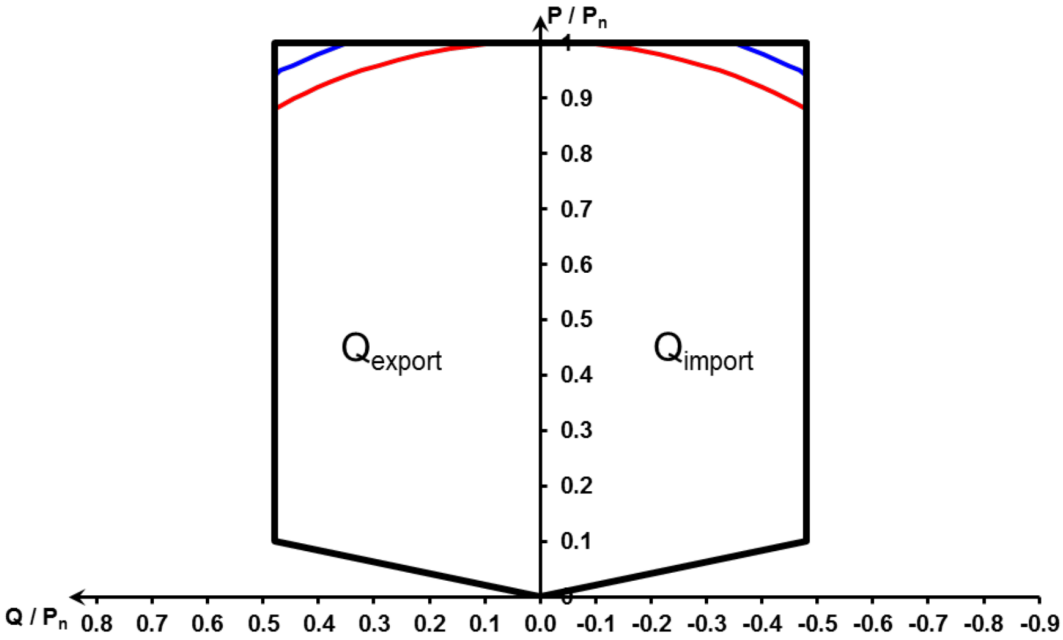


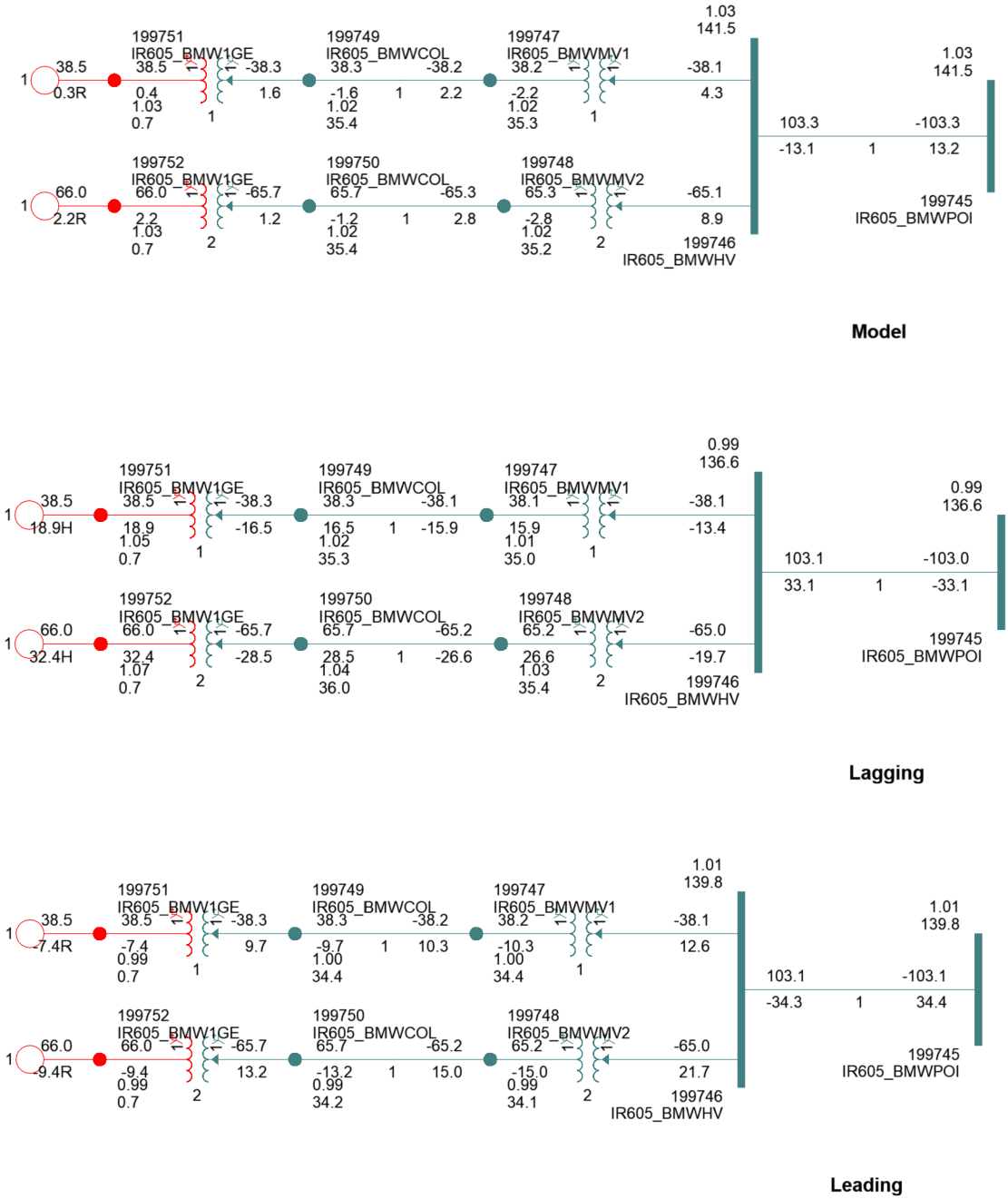
Fig. 1: Reactive power range as determined by the active power and grid voltage

	90 % U_n
	95 % U_n
	≥100 % U_n

Based on the data provided, and the assumed model of the collector circuits, the analysis shown in Figure 5 indicates that IR#605 may be able to meet the full-load reactive power requirement. The model shows that with 19 WECS units (E3-FT version) operating at a total 104.5 MW and 51.3 Mvar, the power delivered to the high side of the ICIF transformers are 38.1 MW & 13.4 Mvar and 65 MW & 19.7 Mvar, respectively; or a overall power factor of 0.952 with WECS terminal voltages at 1.05 and 1.07 p.u.

This configuration would be able to meet the leading power factor requirement of -0.95 at the high side of both ICIF transformers while the WECS are operating at a total of 104.5 MW and -16.8 Mvar at a terminal voltage of 0.99 p.u.

Figure 5: Power Factor Analysis



Because this analysis is based on preliminary transformer data and assumed collector circuit models, reactive capability will be confirmed in the SIS.

A centralized controller will be required which continuously adjusts individual generator reactive power output within the plant capability limits and regulates the voltage at the 34.5 kV bus voltage. The voltage controls must be responsive to voltage deviations at the terminals of the Interconnection Facility substation, be equipped with a voltage set-point control, and also have the ability to slowly adjust the set-point over several (5-10) minutes to maintain reactive power within the individual generator capabilities. The details of the specific control features, control strategy and settings will be reviewed and addressed in the SIS, as will the dynamic performance of the generator and its excitation. Line drop compensation, voltage droop, control of separate switched capacitor banks must be provided.

The NSPI System Operator must have manual and remote control of the voltage set-point and the reactive set-point of this facility to coordinate reactive power dispatch requirements.

This facility must also have low voltage ride-through capability as per Appendix G of the Standard Generator Interconnection and Operating Agreement (GIA). The SIS will state specific options, controls and additional facilities that are required to achieve this.

9 System Security / Bulk Power Analysis

L-6054 is presently not part of Nova Scotia Bulk Power System (BPS), and the ICIF is adjacent to the POI. Therefore, interconnection with line L-6054 will utilize a line tap with single circuit breaker and transfer trip protection to the IR#605 generation facilities. As IR#605 has dispersed generation totalling more than 75 MVA, each generator will be classified as a NERC Bulk Electric System (BES) element. The 34.5 kV bus and the 138kV bus would also be considered BES. There is the potential for an exclusion from BES to be granted for the high side (138kV) bus based on further analysis as per the NS BES Exception Procedure. This analysis will be initiated as part of the System Impact Study (SIS) and exclusion from BES will only be granted upon subsequent approval by the Nova Scotia Utility and Review Board.

10 Expected Facilities Required for Interconnection

The following facility changes will be required to connect IR#605 to the NSPI transmission system at a POI on L-6054 under NRIS:

a. Required Network Upgrades

- Modification of NSPI protection systems to L-6054 at 43V-Canaan Road and 101V-MacDonald Pond to three-terminal line protection.
- Uprate of L-6054 sections between 43V and IR#605 POI from 75°C to 85°C.

b. Required Transmission Provider's Interconnection Facilities (TPIF):

- Construct a line tap on L-6054 with a 138kV circuit breaker.
- Add control and communications between the wind farm and NSPI SCADA system (to be specified).

c. Required Interconnection Customer's Interconnection Facilities (ICIF)

- Facilities to provide 0.95 leading and lagging power factor when delivering rated output at the HV terminals of the IC Substation Step Up Transformer when the voltage at that point is operating between 95 and 105 % of nominal. This study shows that the Enercon model E3-FT may not be able to meet this requirement. The data provided did not meet the requirement that the rated reactive power must be delivered from zero to full rated real power.
- Centralized controls: These will provide centralized voltage set-point controls and are known as Farm Control Units (FCU). The FCU will control the 34.5 kV bus voltage and the reactive output of the machines. Responsive (fast-acting) controls are required. The controls will also include a curtailment scheme which will limit or reduce total output from the facility, upon receipt of a telemetered signal from NSPI's SCADA system.
- NSPI will have control and monitoring of reactive output of this facility, via the centralized controller. This will permit the NSPI Operator to raise or lower the voltage set-point remotely.
- Low voltage ride-through capability as per Section 7.4.1 of the Nova Scotia Power Transmission System Interconnection Requirements (TSIR).
- Real-time monitoring (including an RTU) of the interconnection facilities. Local wind speed and direction, MW and Mvar, as well as bus voltages are required.
- Synthesized inertia (Fast Frequency Response) controls within the WECS.

- Automatic Generation Control to assist with tie-line regulation.
- Operation at ambient temperature of -30°C.

11 NSPI Interconnection Facilities and Network Upgrades Cost Estimate

Estimates for NSPI Interconnections Facilities and Network Upgrades for interconnecting 104.5 MW wind energy at the 138kV POI on L-6054 are included in Table 6.

Table 6 Cost Estimate NRIS @ POI L-6054

Item	Network Upgrades	Estimate
1	Modification of protection systems to L-6054 at 43V-Canaan Road and 101V-MacDonald Pond to three-terminal line protection	$500,000
2	Uprate of L-6054 between 43V and IR#605 (a total of 22.3 km)	$3,345,000
	Sub-total for Network Upgrades	$3,845,000
Item	**TPIF Upgrades**	**Estimate**
1	Line tap with 138kV circuit breaker on L-6054	$1,700,000
2	NSPI P&C relaying equipment	$100,000
3	NSPI supplied RTU	$60,000
4	Tele-protection and SCADA communications	$150,000
	Sub-total for TPIF Upgrades	$2,010,000
	Total Upgrades	**Estimate**
	Network Upgrades + TPIF Upgrades	$5,855,000
	Contingency (10%)	$585,500
	Total (Incl. 10% contingency and Excl. HST)	$6,440,500

The preliminary non-binding cost estimate for interconnecting 104.5 MW at the POI on L-6054 under NRIS is $6,440,500 including a contingency of 10%. In this estimate, $3,845,000 (plus 10% contingency) of the amount represents Network Upgrade costs which are funded by the Interconnection Customer, but eligible for refund under the terms of the GIP. These estimates do not include costs to address any issues that may be identified at the SIS stage based on dynamic analysis.

The estimated time to construct the Transmission Providers Interconnection Facilities is 18-24 months after receipt of funds and cleared right of way from the IC.

The estimated time to construct the Network Upgrades is 24-36 months after receipt of funds from the IC and cleared right of way from the customer.

12 Loss Factor

Loss factor is calculated by running the winter peak load flow case with and without the new facility in service while keeping 91H-Tufts Cove as the Nova Scotia Area Interchange bus. This methodology reflects the load centre in and around Metro.

Without IR#605 in service, losses in the winter peak case total 86.2 MW. With IR#605 in service at the POI of L-6054, displacing generation at 91H, and not including losses associated with the IR#605 Generation Facilities or TPIF Interconnection Facilities, the system losses total 84.8 MW - a decrease of 1.4 MW. The power delivered to the POI is 103.3 MW. Therefore, the loss factor is calculated as -1.4/103.3 = -1.4%.

13 Issues to be addressed in SIS

The SIS will include a more comprehensive assessment of the technical issues and requirements to interconnect generation as requested. It will include contingency analysis, system stability, ride through, and operation following a contingency (N-1 operation). The SIS must determine the facilities required to operate this facility at full capacity, withstand any contingencies (as defined by the criteria appropriate to the location) and identify any restrictions that must be placed on the system following a first contingency loss. The SIS will confirm the options and ancillary equipment that the customer must install to control flicker, voltage, frequency response, active power, reactive power and ensure that the facility has the required ride-through capability. The SIS will be conducted in accordance with the GIP with the assumption that all appropriate higher-queued projects proceed, and the facilities associated with those projects are installed.

The following outline provides the minimum scope that must be complete in order to assess the impacts. It is recognized that the actual scope may deviate to achieve the primary objectives.

The assessment will consider but not be limited to the following:

- Contingency analysis for both steady state and system stability.
- Ride-through and operation following a contingency (n-1 operation).
- The minimum transmission and substation additions/upgrades that are necessary to permit operation of this generating facility, under all dispatch conditions, catering to, at a minimum, the first contingencies listed below.
- Options and ancillary equipment that the customer must install to control flicker, voltage and ensure that the required ride-through capability.

- Identify guidelines and restrictions applicable following a first contingency (curtailments, etc.).
- Loss Factor.
- Determination of BPS designation.
- Changes to SPS schemes required for operation of this generating facility.
- Under-frequency load shedding.
- Facilities that the customer must install to meet the requirements of the GIP.

Parameters for a generic model must be supplied for transient analysis in PSS®E.

The SIS will determine the facilities required to operate this facility at full capacity, withstand the contingencies as defined by NPCC/NERC and identify any restrictions that must be placed on the system following a first contingency loss. The SIS will be conducted with the assumption that all projects higher queued will proceed and the facilities associated with those projects are installed.

Any changes to SPS schemes required for operation of this generating facility, in addition to existing generation and facilities that can proceed before this project, will be determined by the SIS as well as any required additional transmission facilities. The determination will be based on all NERC and NPCC criteria approved by the UARB as well as NSPI guidelines and good utility practice. The SIS will also determine the contingencies for which this facility must be curtailed.

A thorough assessment will be provided to ensure that the facilities will meet applicable NSPI, NPCC and NERC transmission design criteria.

Nova Scotia Power
Transmission System Operations
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